NASA TT F-10,305

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TEMPERATURE OF THE ATMOSPHERE IN THE REGION OF THE MESOPAUSE AND DISTRIBUTION OF NOCTILUCENT CLOUDS

V. V. Mikhnevich

Translation of "Temperatura atmosfery v oblasti mezopauzy i raspredeleniye serebristykh oblakov"
Meteorological Investigations. Noctilucent Clouds
(Meteorologicheskiye Issledovaniya. Serebristyye Oblaka).
IGY Program, Section II, No. 12,
Izdatel'stvo Nauka, pp. 84-87, Moscow, 1966

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON OCTOBER 1966

TEMPERATURE OF THE ATMOSPHERE IN THE REGION OF THE MESOPAUSE AND DISTRIBUTION OF NOCTILUCENT CLOUDS

V. V. Mikhnevich

ABSTRACT

The report considers seasonal and latitudinal dependence of temperature in order to investigate the correlation between temperature mesopause and noctilucent cloud distribution. The existence of the full correlation of such a type is established. This fact confirms the great role of temperature in noctilucent cloud formation.

There are now two principal hypotheses of the origin of noctilucent clouds: condensation and dust (ref. 1). According to the condensation theory, the formation of noctilucent clouds requires a low temperature. For example, for a water vapor content in air of $a = 10^{-3}$ (a is the ratio of concentrations of water molecules to the total concentration of all molecules), the formation of noctilucent clouds by condensation requires a temperature of $174^{\circ}K$; when $a = 10^{-4}$, $T = 162^{\circ}K$; when $a = 10^{-5}$, $T = 153^{\circ}K$ (ref. 1). /84*

Such a low temperature has been recorded in various experiments, including those described in references 2, 3 and 4; a seasonal and latitudinal effect was detected in the temperature change (ref. 5).

*Numbers given in margin indicate pagination in original foreign text.

Many observations of noctilucent clouds have been made. These observations have given the latitudinal and seasonal distribution of the appearance of clouds (ref. 6). A number of authors (refs. 1 and 7) have noted the presence of a relationship between the seasonal and latitudinal variations of temperature in the region of the mesopause and the appearance of noctilucent clouds. However, a detailed comparison of these two phenomena has yet to be made. What is the correlation between the temperature of the mesopause and the distribution of noctilucent clouds?

In order to answer this question we will consider in greater detail the seasonal and latitudinal effects in the temperature change in the region of the mesopause, using for this purpose data on temperature given in reference 5.

In reference 6 we used the results of experiments at 15 stations: 71, 59, 40, 38, 34, 33, 28, 22, 13, 11° N and 31° S; two stations each were situated at 38 and 32° N. The number of experiments at different heights was dissimilar; at a height of 60 km there were approximately 300 and at a height of 80 km, about 20.

In processing the results, the diurnal effect was not taken into account (it is assumed that the temperature change during the day does not exceed 10 percent).

Figures 1 and 2 show the change of atmospheric temperature at a height of 80 km as a function of the season of the year for different latitudes of the northern and southern hemispheres.

Analysis of the data reveals that the minimum temperature value is observed at different seasons of the year at different latitudes. For example, in the northern hemisphere at latitude $\varphi = 20^{\circ}$ the minimum temperature value

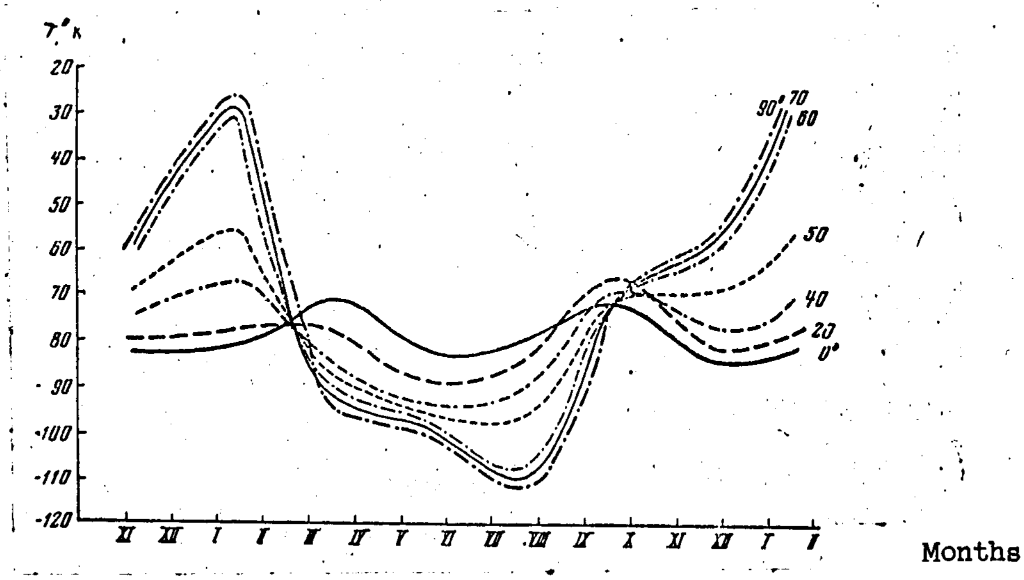

Figure 1. Atmospheric temperature at height of 80 km as function of season of year for different latitudes of northern hemisphere.

is in late May-early June, at latitude $\varphi = 40^o$--in June; $\varphi = 50^o$--in July; $\varphi = 60^o$--late in July-early August.

There are two temperature minima at the equator and to a latitude of approximately 50^o. /85

The seasonal temperature change does not exceed an average of 12^o at the equator, increases with latitude and at latitude 90^o attains approximately 100^o.

The minimum temperature value depends on latitude (fig. 3); at latitude $\varphi = 90^o$ $T_{min} = 160^oK$; $\varphi = 60^o$ $T_{min} = 165^oK$; $\varphi = 50^o$ $T_{min} = 175^oK$; $\varphi = 40^o$ $T_{min} = 180^oK$; $\varphi = 20^o$ $T_{min} = 185^oK$; $\varphi = 0^o$ $T_{min} = 190^oK$. From late May through September at latitudes more northerly than 60^o N the temperature is relatively low (less than 180^oK).

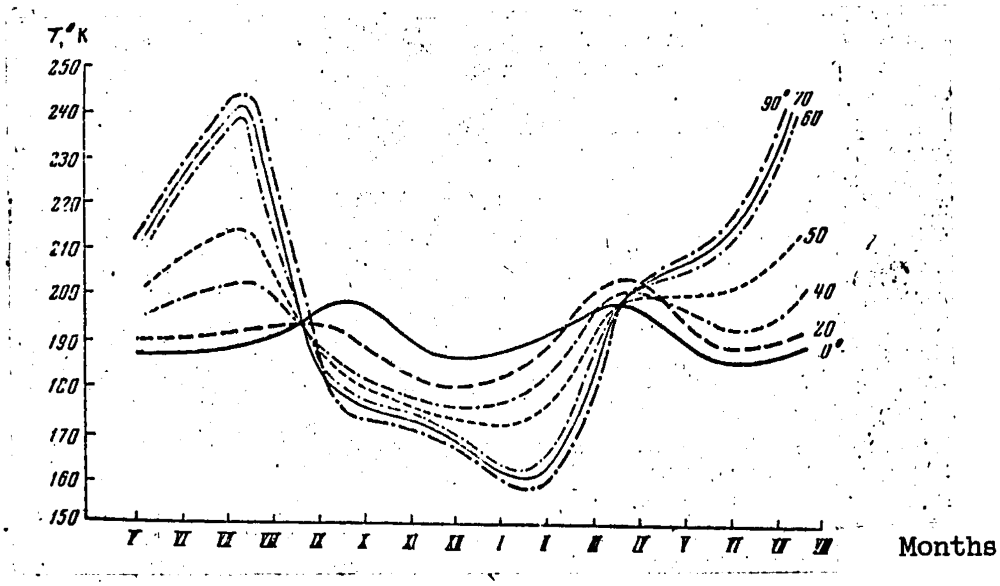

Figure 2. Atmospheric temperature at height of 80 km as function of season of year for different latitudes of southern hemisphere.

On the basis of these temperature changes in the region of the mesopause a number of hypotheses can be formulated with respect to the probable distribution of noctilucent clouds. When there is sufficient water content in the atmosphere, in accordance with the seasonal and latitudinal changes of temperature the maximum probability of the appearance of noctilucent clouds in the middle latitudes of the northern hemisphere is in summer. The maximum moves from the low latitudes to the higher latitudes during the year. As follows from these data (fig. 1), the maximum frequency of ~~occorrence~~ occurrence of noctilucent clouds at latitude 40° should be in June, at latitude 50°--in July, at latitude 60°--in late July-early August. /86

The existence of two temperature minima at latitudes 0-45° makes it possible to postulate two periods of occurrence of noctilucent clouds at these latitudes. In accordance with the minimum temperature values at different

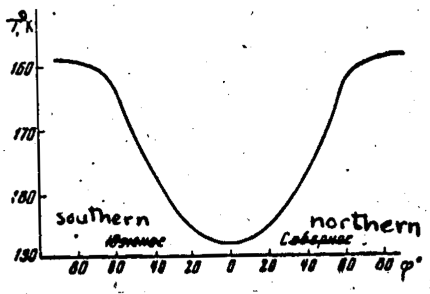

Figure 3. Minimum temperatures at height of 80 km for different latitudes.

latitudes (fig. 3), the probability of appearance of noctilucent clouds at latitudes 0-45° is considerably less than at latitudes 50-60°. The probability of the appearance of noctilucent clouds at latitudes 60-90° is not less than in the region φ = 50-60°.

A similar consideration of temperature data for the southern hemisphere permits us to postulate that the maximum probability of appearance of noctilucent clouds can be expected in October-January; the maximum sets in at different latitudes with a seasonal shift. To the north of 45° S the probability of appearance of noctilucent clouds is far less than at greater latitudes. As in the northern hemisphere, in the case of sufficient air humidity the probability of formation of noctilucent clouds at high latitudes ($\varphi > 60^\circ$) is not less than at latitudes 50-60°.

Since there have been few direct determinations of temperature in the region of the mesopause in the southern hemisphere, these data on temperature and the conclusions on the distribution of noctilucent clouds in the southern hemisphere are hypothetical.

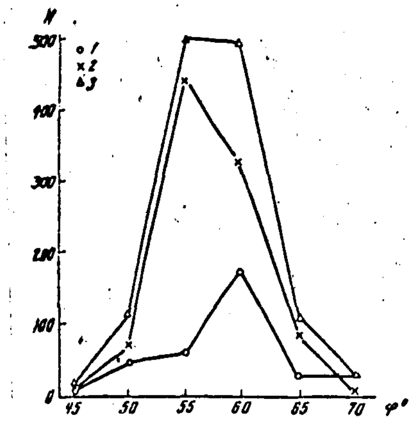

Figure 4. Distribution of number of cases of appearance of noctilucent clouds as function of season of year for different latitudes. 1, 1957; 2, 1958; 3, mean for 1957-1958.

What distribution of the appearance of noctilucent clouds has been obtained as a result of observations, and does it agree with the distribution based on the temperature data considered above?

Figure 4 gives the distribution of the number of cases of visibility of noctilucent clouds as a function of the season of the year for different latitudes. Figure 5 shows the latitudinal distribution of the number of cases of visibility of noctilucent clouds (ref. 6).

The data show that the actual distribution of the number of cases of visibility of noctilucent clouds in the northern hemisphere corresponds to a distribution obtained on the basis of consideration of the temperature curves, that is: the maximum number of cases of visibility in the middle latitudes is in summer; with northward movement the maximum number of cases of visibility sets in increasingly later. According to the data in reference 6, in 1957-1958

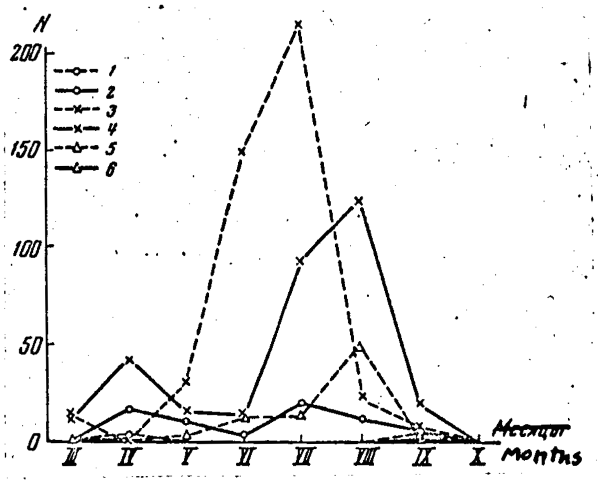

Figure 5. Latitudinal distribution of number of cases of visibility of noctilucent clouds. 1, 45°; 2, 50°; 3, 55°; 4, 60°; 5, 65°; 6, 70°.

at latitude $\varphi = 50^{\circ}$ N the maximum number of cases of visibility was in July, $\varphi = 60^{\circ}$ N--in August, $\varphi = 70^{\circ}$ N--in September; at latitude 45° N noctilucent clouds were visible during two periods--in April and in September 1958. The observed latitudinal distribution of the number of cases of visibility of noctilucent clouds corresponds to the latitudinal distribution obtained using temperature data. For latitudes greater than 60° the observations do not agree with the temperature data. This in all probability is due to the poor conditions for visibility of noctilucent clouds at these latitudes (polar day) and the small number of observations. From the temperature data we should expect (in the case of adequate air humidity) the existence of noctilucent clouds at latitudes greater than 60°.

On the basis of these data it can be concluded that there is full /87 correlation between temperature in the region of the mesopause and the appearance of noctilucent clouds. Temperature plays an important role in the formation of noctilucent clouds.

In conclusion the author wishes to note that noctilucent clouds merit study not only as an interesting natural phenomenon, but also as an important method of study of the processes and phenomena transpiring in the upper atmosphere. For this reason noctilucent clouds are being studied for determination of the character of movement of air masses, We feel that investigations of noctilucent clouds can also be used for study of the relative temperature changes in this region.

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